WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Ground-Water Age Dating as a Tool to Assess Land-Use Effects on Recharge and Water Quality in Intermontane Basins

Focus Categories: GW, HYDGEO, WQL

Keywords: Groundwater Movement, Groundwater Quality, Groundwater Recharge, Tritium/Helium Isotopes, Chlorofluorocarbons (CFC's), Surface-Groundwater Relationships

Duration: July 1, 1999-June 30, 2000

Federal Funds Requested: $ 14,380

Non-Federal (match): $ 28,906

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Congressional District: First (at large), Montana

Statement of Problem

Intermontane basins of the Northen Rocky Mountains contain alluvial aquifers that store and yield large quantities of water. In many basins these aquifers are the sole sources of municipal and domestic water. The basins also contain perennial streams and associated riparian habitats that are sustained by ground-water discharges. Population growth in these basins is occurring at an unprecedented rate and is resulting in an increased demand for water (municipal/domestic) and a shift in land use from agricultural to residential/urban. The increased demand for water and the land-use shift have created serious needs for information and techniques to evaluate vulnerable hydrologic systems to assure water supplies and to avoid degradation of the ground-water resource.

The proposed research will evaluate the use of tritium-helium isotopes and chlorofluorocarbons to date young ground water (0.1-45 years old) in the Missoula Valley aquifer. The results will be applicable to, and provide a base for, investigations of ground-water age, recharge and flow in other intermontane valleys where population growth and land-use changes are actively occurring (e.g., Bitterroot Valley, Gallatin Valley, Helena Valley, Mission Valley, Kalispell Valley, Paradise Valley).

Statement of Benefits

Understanding the dynamics of ground-water recharge and flow is essential for protection and management of ground-water resources. Accurate dates of young water can provide a powerful tool for defining the recharge rate and evaluating the rate of ground-water movement through alluvial aquifers. The age of ground water also can be used to evaluate the relative importance of different recharge sources and land-use practices on water quality, and to develop source-water protection strategies. With an accurate understanding of ground-water recharge and travel times, water managers and citizens can make informed decisions about management practices to protect the quality and quantity of shallow aquifers that serve as sources of municipal/domestic water and sustain streams in intermontane basins. Ground-water age determinations can also provide valuable supplemental data for evaluating nonpoint source pollution, assessing conjunctive use strategies, and evaluating the efficiency of irrigation canal systems and the magnitude of irrigation return flows.

Nature and Scope of the Problem

Intermontane basins are structurally down-dropped relative to the surrounding mountains and are filled with unconsolidated to poorly consolidated deposits. In western Montana, the basin-fill deposits can range up to several thousand feet thick and contain complex sequences of aquifers that are a vital water source. Generally, the shallow alluvial aquifers are among the most productive and utilized aquifers in the region (Briar et al., 1996). The alluvial aquifer in the Missoula Valley has been designated as a sole-source aquifer for the city of Missoula by the U.S. Environmental Protection Agency; most households in the basins rely on wells for domestic use; and ground water is also used for stock, irrigation, and industrial use (Kendy and Tresch, 1996). In 1985, it was estimated that about 100 million gallons of water per day were withdrawn from aquifers in the intermontane basin area of western Montana (Clark and Kendy, 1992). The basins also host perennial streams, associated flood plains and riparian areas that are sustained by ground-water discharges from shallow alluvial aquifers. Therefore, ground water in intermontane basins plays an important role in sustaining human populations, fisheries, and wildlife habitats.

Most of the population in western Montana resides within intermontane basins, and the population has been growing at an unprecedented rate. During the 1990's, Ravalli County's (Bitterroot Valley) population increased 34.3 percent, Flathead County (Flathead Valley) increased 20.3 percent, Lake County (Mission Valley) increased 18.4 percent, Gallatin County (Gallatin Valley) increased 20 percent, Missoula County (Missoula Valley) increased 12.5 percent, and Lewis and Clark County (Helena Valley) increased 12.3 percent (J. Ludwick, The Missoulian, March 3, 1997). The increase in population has placed an increased demand for water and in some areas raised concerns about the available supply. In Missoula County, the Montana Department of Natural Resources (DNRC) recently created a Controlled Groundwater Area to restrict new ground-water uses in the Hayes Creek drainage. An application to establish another Controlled Groundwater Area on the Sunset Bench in Ravalli County was submitted (and subsequently withdrawn) to the DNRC. The Montana Department of Environmental Quality recently denied a subdivision approval in Ravalli County because of concerns that there was insufficient ground water to meet the demand (Dennis McKenna, MDEQ, oral commun. 1998). The concerns about the available supply are very real for those with an interest in developing and managing ground-water resources.

The population growth has also caused a shift in land use. Areas that were once agricultural are now becoming residential. Within the basins, unsewered subdivisions that rely on private septic systems are being developed on land formerly used for crops or range. As cities grow and expand, agricultural or undeveloped land is being converted to residential, commercial, and industrial uses. Land use can affect ground-water quality, especially in sensitive hydrogeologic settings such as the surficial alluvial aquifers present in intermontane basins. Septic systems have been found to degrade underlying ground water (Woessner et al., 1995); increased nitrate concentrations and pesticide detections in ground water are more common in residential areas (Eckhardt and Stackelberg, 1995; Mullaney and Grady, 1997); and increased nitrate concentrations and volatile organic compound detections are prevalent in commercial and industrial areas (Eckhardt and Stackelberg, 1995; Mullaney and Grady, 1997). The change in land use and the urban sprawl, which are occurring in many basins, have raised concerns about the potential for degradation of the ground-water resources.

Ground-water age (the time since water entered the aquifer), in conjunction with geologic and hydrogeologic information, can provide a better understanding of the link between land use and water quality. By comparing ground-water age and water chemistry, the time needed for water-quality changes to propagate through the system can be evaluated; this, in turn, can be related to the history of land use. Furthermore, knowing the distribution of ground-water age within an aquifer system can provide a powerful tool for evaluating the recharge rate and spatial variations in recharge rate, as well as for defining the rate of ground-water movement through the aquifer. This type of information can help land and water planners make informed decisions regarding the available supply of ground water, aquifer protection strategies, and the relative importance of land-use practices on the quality of ground water.

Objectives of the Research

The objective of the proposed research will be to evaluate the use of tritium-helium isotopes and chlorofluorocarbons (CFC's) to date young ground water (0.1-45 years old) in an intermontane alluvial aquifer. The overall goal of the research is to improve the technical basis for ground-water protection and management in intermontane alluvial aquifers affected by population increases and land-use changes. Direct measurement of ground-water ages can be used to trace recharge and determine ground-water flow velocities. Ground-water ages have been successfully determined for young ground water (less than 45 years old) with a precision on the order of months using tritium-helium isotopes, and a precision of less than 2 years using CFC's.